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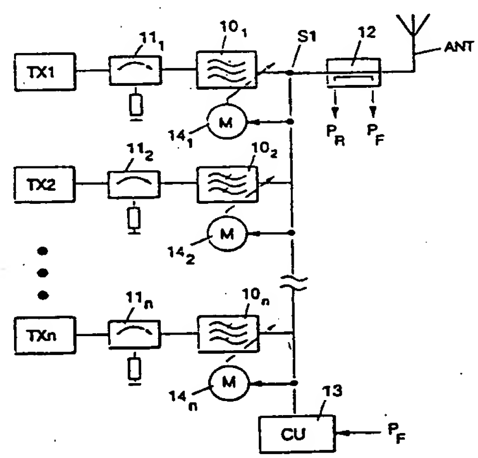


(57) Abstract

The invention relates to a method for tuning an RF bandpass filter, especially a combiner filter ($10_1$, $10_2$..., $10_n$) belonging to a GSM system. In the method, an RF signal having a certain nominal carrier frequency ($f_c$) is inputted into the RF bandpass filter and a medium frequency of a pass band of the RF bandpass filter is tuned depending on an RF power propagating through the bandpass filter or on an RF power reflected from an input of the bandpass filter. For an easier tuning of the filter and for a tuning accuracy better than before, (a) a carrier is modulated by a signal causing a first predetermined offset ($+\Delta f$), of the carrier frequency, (b) a medium frequency, at which the power propagating through the filter is at the maximum or the power reflected from the input of the filter is at the minimum, is searched for the bandpass filter, (c) the first medium frequency obtained at stage (b) is stored, (d) the carrier is modulated by a signal causing a second predetermined offset ($-\Delta f$) of the carrier frequency, (e) a medium frequency, at which the power propagation through the filter is at the maximum or the power reflected from the input of the filter is at the minimum, is searched for the bandpass filter, (f) the second medium frequency obtained at stage (e) is stored, and (g) the filter is tuned by tuning its medium frequency to a value determined on the basis of the frequency values obtained at stages (c) and (f).

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# A method for tuning an RF bandpass filter

The invention relates to methods according to the preambles of the attached claims 1 and 3 for tuning an RF bandpass filter.

The methods according to the invention are intended to be used especially for tuning so-called combiner filters of a GSM system or a similar mobile phone network, but they can also be applied to bandpass filters suitable for other purposes, the frequency control of which filters requires a power measurement at selective frequency.

A combiner is a device by means of which many transmitters are connected to the same antenna or antenna line. Each radio transmitter is then connected to an antenna or antenna line via a separate bandpass filter, a so-called combiner filter. Medium frequency of each bandpass filter is tuned to the medium frequency of the respective radio transmitter. The object of the filters is, on the one hand, to input a transmission signal of a separate radio transmitter into the antenna at losses as low as possible and, on the other hand, to prevent as effectively as possible an entrance of transmission signals at different frequencies from the other radio transmitters into this separate radio transmitter from the antenna direction. Traditionally, combiner filters have been tuned fixedly to the transmission frequencies of radio transmitters. Then it has not been possible to change the transmission frequency of a radio transmitter without changing the combiner filter or the tuning thereof at the same time.

However, it is often desirable to be able to change the frequencies of radio transmitters in a simple and quick manner. One such case is a base sta-

tion of a cellular mobile phone system, for instance, with particular transmission and reception channels allocated for said base station. If the channel allocation of the system can be changed when required by changing the transmission and reception frequencies of the base stations, it is possible to utilize the channel capacity of the system flexibly and effectively under changing circumstances. For this reason, combiner filters have been developed, the medium frequency of which is automatically changed when the transmission frequency changes.

The tuning of these automatically tuned combiner filters is based on a measurement of an RF power reflected from an input of the filters or an RF power passing through the combiner filters. The medium frequency of the filter is locked at a frequency at which the reflected power is at the minimum or the propagating power at the maximum.

In GSM and PCN mobile phone networks, a so-called GMSK (Gaussian Minimum Shift Keying) modulation serves as a method of modulating a transmitter signal. This modulation method is a relatively broadband one for signals corresponding to practical conditions, which leads to that it is difficult to tune combiner filters to a correct frequency and the tuning accuracy achieved remains rather modest.

The object of the present invention is thus to provide a method by means of which combiner filters can be tuned to a correct frequency more accurately than previously. This is achieved by means of the method according to a first embodiment of the invention, which is characterized in what is set forth in the characterizing portion of the attached claim 1, or by means of the method of a second embodiment of the invention, which is characterized in what is set

forth in the characterizing portion of the attached claim 3.

The basic idea of the invention is to search for a bandpass filter for a medium frequency, at which the power propagating through the filter is at the maximum or the power reflected from the input of the filter at the minimum, (at least) twice by using in both cases such a modulation signal which provides the spectrum of the signal to be obtained as a result of the modulation with a sharp peak (a carrier) at a predetermined frequency, and to determine the final frequency on the basis of (at least) two tuning values obtained from the tunings carried out on grounds of these RF signals.

By means of the solution of the invention, an RF bandpass filter can be tuned to a correct frequency in an easier and more accurate way than previously.

In the following, the invention and the preferred embodiments thereof are explained in more detail with reference to the examples according to the attached drawings, in which

Figure 1 shows a block diagram of a typical transmitter system implemented by combiner filters, in which system a medium frequency of a passband of a bandpass filter (combiner filter) is tuned depending on an RF power propagating through the filter,

Figure 2 shows a block diagram of a typical transmitter system implemented by combiner filters, in which system a medium frequency of a passband of a bandpass filter (combiner filter) is tuned depending on an RF power reflected from an input of the filter,

Figure 3 shows a block diagram of a GMSK modulator known per se, which is used in the transmitters illustrated in Figure 1 and 2,

Figure 4a shows a typical spectrum of a GMSK modulation,

Figure 4b shows a spectrum of a first signal to be used in a method according to the invention, and

Figure 4c shows a spectrum of a second signal to be used in the method according to the invention.

Figure 1 shows a radio transmitter system belonging to a GSM mobile phone network or the like, which system comprises n radio transmitters TX1, TX2 ...TXn having respective transmission frequencies f1, f2...fn situated within the range of 920 to 960 MHz, for instance. Each radio transmitter is connected via bandpass filters $10_1$, $10_2$...$10_n$ tuned to respective frequencies to a common summing point S1 and further via a directional coupling means 12 to a common transmitting antenna ANT. (A connection of each transmitter to the corresponding bandpass filter occurs in this example via a circulator $11_1$, $11_2$ and $11_n$, respectively. However, circulators are not necessary for the invention.) Consequently, a signal to be inputted into the transmitting antenna ANT includes the frequencies of all transmitters. The bandpass filters $10_1$, $10_2$...$10_n$ shown in Figure 1 and connecting several transmitters to the common antenna are generally called combiner filters.

The radio transmitter system additionally comprises a control unit 13 controlling a stepper motor $14_1$, $14_2$ and $14_n$, respectively, belonging to each combiner filter, each stepper motor tuning a medium frequency of the respective combiner filter. Each filter is a narrowband filter, the medium frequency of which shall be tuned as close as possible to the frequency of a transmission carrier so that the signal to be transmitted moves to the antenna ANT at losses as low

as possible. In the example of Figure 1, the medium frequency is tuned in a manner known per se depending on an RF power propagating through the bandpass filter. By means of the directional coupler 12, a sample signal $P_F$ is taken of an output signal of each filter separately, which sample signal is proportional to the signal power at transmission frequency passed through said filter. The sample signal is inputted into the control unit 13, which tunes the medium frequency of the filter by means of the stepper motor in such a way that the level of the sample signal is at the maximum.

The example of Figure 2 corresponds to the embodiment of Figure 1, except that each combiner filter $10_1 \ldots 10_n$ now is tuned in another manner known per se, i.e. depending on an RF power reflected from an input of a combiner filter. For this reason, the antenna line has no directional coupler, but to each transmitter branch, to the input of the combiner filter, is connected a separate directional coupling means $12_1$, $12_2$ and $12_n$, respectively. In this case, a sample signal $P_R$ is taken of a signal component reflected from the input of the filter by each directional coupler, which sample signal is proportional to the power of the signal component and inputted into the control unit 13. By means of each stepper motor, the control unit 13 tunes the medium frequency of the respective filter in such a way that the level of the sample signal is at the minimum.

Above have been described the two known ways of tuning a combiner filter on which the method of the invention is based. The stages of the method according to the invention will be explained in more detail in the following.

Figure 3 shows a block diagram of a GMSK modulator known per se and belonging to the transmitters TX1...TXn and Figure 4a in turn a typical signal spectrum S1 obtained as a result of a GMSK modulation. The GMSK modulator comprises a coding unit 31, a Gaussian filter 32, to which the output of the coding unit is connected, and a modulation unit 33, to which the output of the filter is connected. In the coding unit, a differential coding of incoming data is performed, the coded signal is filtered in the Gaussian filter 32 and the filtered signal is modulated to carrier frequency in the modulation unit 33. Because the structure of the GMSK modulator is known per se and does not relate to the actual inventive idea, it is not described more accurately in this connection. The operation of the modulator appears in greater detail e.g. from the paragraphs 2.4 to 2.6 of the GSM specification 05.04 (version 3.1.1).

The spectrum S1 of an RF signal to be obtained from the output of the modulation unit 33 and to be inputted into a combiner filter is typically similar to the spectrum shown in Figure 4a, i.e. relatively broad. Then data to be transferred in a practical situation or random data reminding of the data to be transferred in a practical situation have served as modulating data.

However, a property of GMSK modulation is that the spectrum of the signal to be obtained as a result of modulation is provided with a sharp peak (a carrier) at a predetermined frequency deviating from the actual nominal carrier frequency $f_c$ ($f_c$ is f1, f2 etc. or fn), when a particular predetermined bit queue is used as modulating data. In other words, the carrier occurs as a sharp peak at a frequency which has been offset a predetermined distance from the nominal car-

rier frequency. For instance, when a bit queue 11111... is used, said spectrum peak is offset about +(1/4T) from the nominal carrier frequency, 1/T being the transmission rate to be used (in a GSM system, the transmission rate is 270,833 kbit/s). Correspondingly, when a bit queue 010101... is used, said spectrum peak is offset about -(1/4T) from the nominal carrier frequency.

According to the invention, this property is utilized at the tuning of combiner filters in such a way that the carrier is at first modulated e.g. by the bit queue 1111... indicated by reference mark A1 in Figure 3. Then a spectrum S2 of an RF signal to be obtained from the modulation unit 33 to the input of a combiner filter is similar to the spectrum shown in Figure 4b. The spectrum now comprises a sharp peak (a carrier) at a frequency which has been offset about $+ \Delta f$ ($\Delta f=1/4T$) from the nominal carrier frequency $f_c$. By using this signal, a medium frequency, at which the power propagating through the filter is at the maximum or the power reflected from the input of the filter is at the minimum, is searched for for the combiner filter, i.e. either the method illustrated in Figure 1 or the method illustrated in Figure 2 is used. The first information of a medium frequency obtained in this way is stored.

At the following stage, the carrier is modulated for instance by the bit queue 010101... indicated by reference mark A2 in Figure 3. A spectrum S3 of an RF signal obtained from the modulation unit to the input of a combiner filter is then similar to the spectrum shown in Figure 4c. The spectrum has now a sharp peak (a carrier) at a frequency which has been offset about $-\Delta f$ ($\Delta f=1/4T$) from the nominal carrier frequency $f_c$. (In practice, the spectrums S1 and S2 to

be obtained as a result of modulation comprise weaker components at other frequencies, too, but for the sake of clarity, they are not shown in the Figures 4b and 4c). By using this second signal, a medium frequency, at which the power propagating through the filter is at the maximum or the power reflected from the input of the filter is at the minimum, is again searched for for the combiner filter. In other words, either the method illustrated in Figure 1 or the method illustrated in Figure 2 is reused. The second information of a medium frequency obtained in this way is stored.

The last stage is the final tuning of the combiner filter by tuning the medium frequency midway between the first and the second medium frequency information.

Though the invention has been described above with reference to the example of the attached drawings, it is clear that the invention is not restricted to it, but can be modified in many ways within the scope of the inventive idea described above and in the attached claims. Accordingly, even if the invention has been explained referring to a combiner filter belonging to a GSM system, for instance, the invention can also be applied to other systems using GMSK modulation or to other modulation methods having the properties in question. In principle, the method can also be implemented in such a way that the first and second offset of the carrier frequency have unequal absolute values. In the above example, this means that different transmission rates are used at the respective stages of the method. Moreover, the methods can be combined, which means that a measurement of both the reflected RF power and the RF power passed through are used for tuning in such a manner

that the control unit each time selects the way of tuning depending on external load. Because different load situations affect the sample signals $P_F$ and $P_R$ in different ways, this combined tuning method can reduce the influence of these external loads on the tuning.

Claims:

1. A method for tuning an RF bandpass filter, especially a combiner filter ($10_1$, $10_2 \ldots 10_n$) belonging to a GSM system or the like, in which method an RF signal having a certain nominal carrier frequency ($f_c$) is inputted into the RF bandpass filter and a medium frequency of a pass band of the RF bandpass filter is tuned depending on an RF power propagating through the bandpass filter, c h a r a c t e r i z e d by stages, at which

(a) a carrier to be inputted into the filter ($10_1$, $10_2 \ldots 10_n$) is modulated by a signal causing a first predetermined offset ($+\Delta f$) of the carrier frequency from the nominal frequency ($f_c$) thereof,

(b) a medium frequency, at which the power propagating through the filter is at the maximum, is searched for for the bandpass filter,

(c) the first medium frequency obtained at stage (b) is stored,

(d) the carrier to be inputted into the filter ($10_1$, $10_2 \ldots 10_n$) is modulated by a signal causing a second predetermined offset ($-\Delta f$) of the carrier frequency from the nominal frequency ($f_c$) thereof,

(e) a medium frequency, at which the power propagating through the filter is at the maximum, is searched for for the bandpass filter,

(f) the second medium frequency obtained at stage (e) is stored, and

(g) the filter is tuned by tuning its medium frequency to a value determined on the basis of the frequency values obtained at stages (c) and (f).

2. A method according to claim 1, c h a r a c t e r i z e d in that, at stages (a) and (d), the

carrier is modulated by signals causing substantially equal offsets of the carrier frequency, but in opposite directions, whereby the filter is tuned at stage (g) midway between the frequency values obtained.

3. A method for tuning an RF bandpass filter, especially a combiner filter ($10_1$, $10_2$...$10_n$), in which method an RF signal having a certain nominal carrier frequency ($f_c$) is inputted into the RF bandpass filter and a medium frequency of a pass band of the RF bandpass filter is tuned depending on an RF power reflected from an input of the bandpass filter, characterized by stages, at which

(a) a carrier is modulated by a signal causing a first predetermined offset ($+\Delta f$) of the carrier frequency,

(b) a medium frequency, at which the power reflected from the input of the filter is at the minimum, is searched for for the bandpass filter,

(c) the first medium frequency obtained at stage (b) is stored,

(d) the carrier is modulated by a signal causing a second predetermined offset ($-\Delta f$) of the carrier frequency,

(e) a medium frequency, at which the power reflected from the input of the filter is at the minimum, is searched for for the bandpass filter,

(f) the second medium frequency obtained at stage (e) is stored, and

(g) the filter is tuned by tuning its medium frequency to a value determined on the basis of the frequency values obtained at stages (c) and (f).

4. A method according to claim 3, characterized in that, at stages (a) and (d), the carrier is modulated by signals causing substantially equal offsets of the carrier frequency, but in oppo-

site directions, whereby the filter is tuned at stage (g) midway between the frequency values obtained.

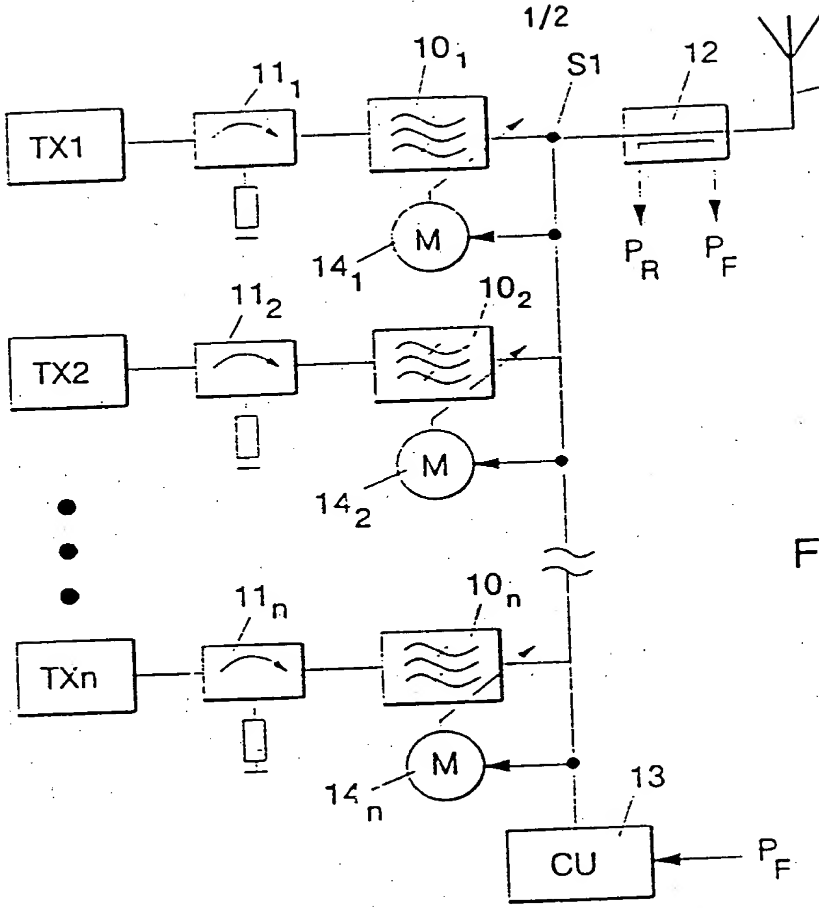
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FIG. 1

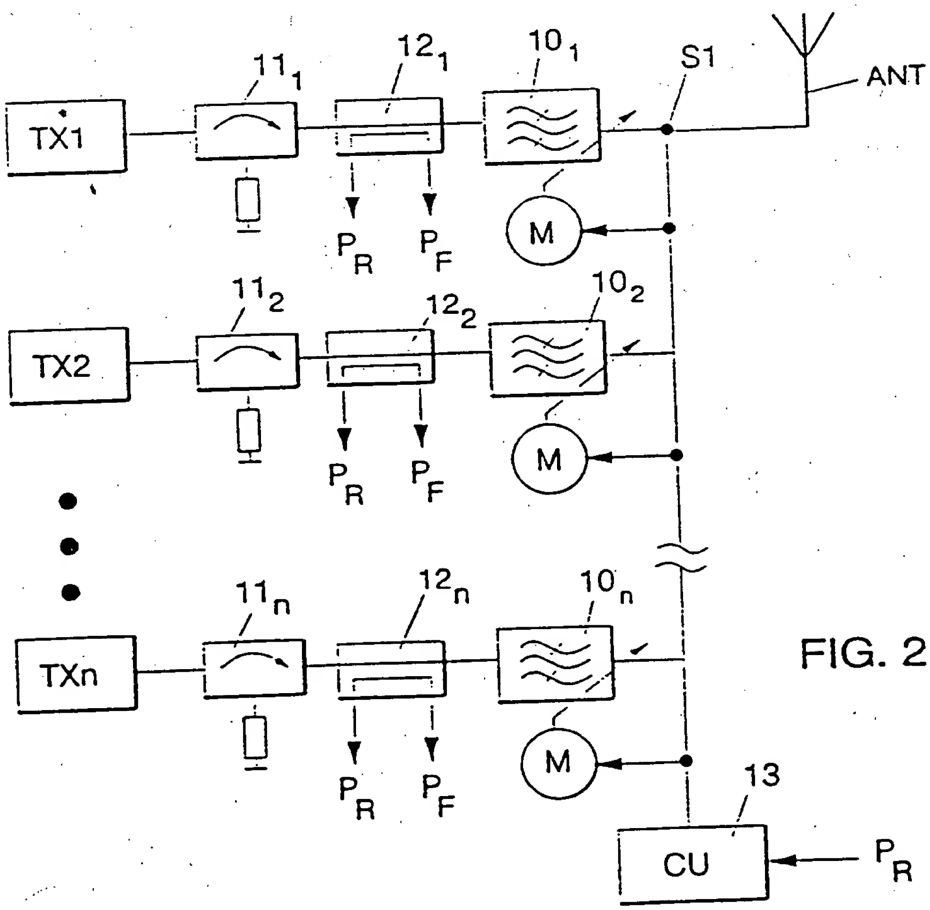
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FIG. 2

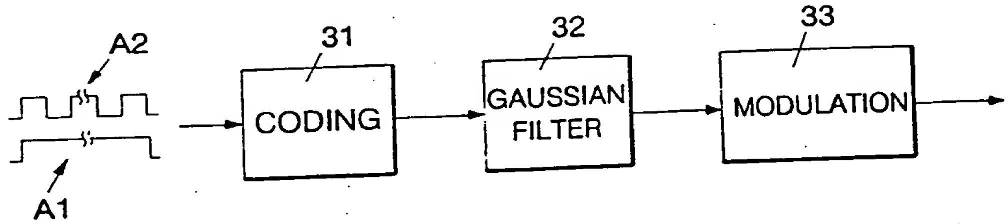


FIG. 3

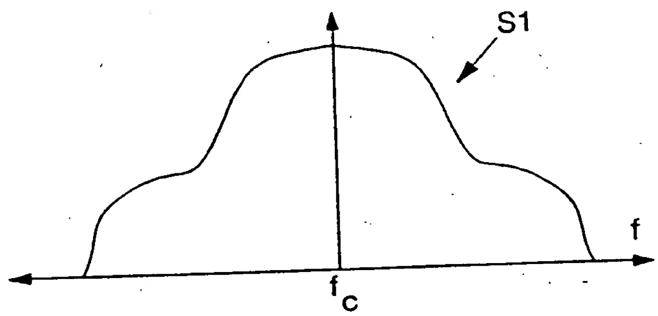


FIG. 4a

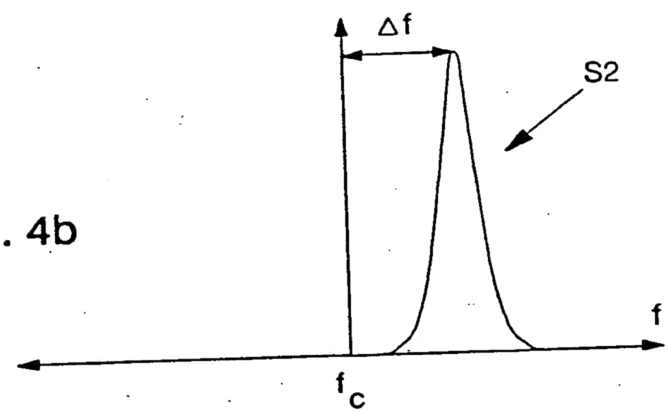


FIG. 4b

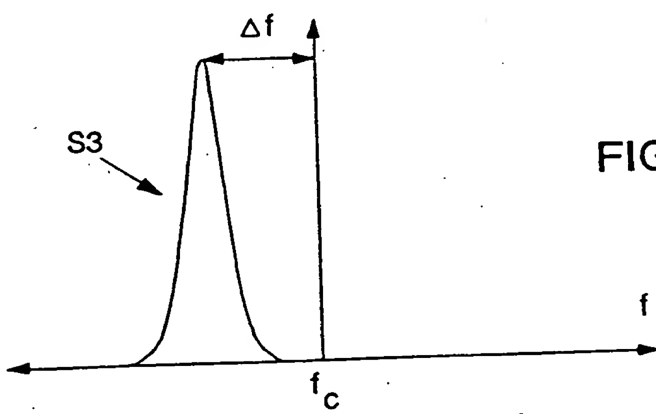


FIG. 4c

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 93/00128

## A. CLASSIFICATION OF SUBJECT MATTER

IPC5: H03J 3/00, H02J 7/02
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

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IPC5: H03J, H03H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US, A, 4726071 (RONALD E. JACHOWSKI), 16 February 1988 (16.02.88), column 2, line 34 - column 3, line 25; column 4, line 63 - column 5, line 59 | 1-4 |
| | -- | |
| A | EP, A1, 0494058 (TELEFONAKTIEBOLAGET L M ERICSSON), 8 July 1992 (08.07.92), column 1, line 1 - line 39 | 1-4 |
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INTERNATIONAL SEARCH REPORT
Information on patent family members

28/05/93

International application No.
PCT/FI 93/00128

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US-A- 4726071 | 16/02/88 | NONE | |
| EP-A1- 0494058 | 08/07/92 | CA-A- 2058146 | 22/06/92 |
| | | SE-B,C- 467717 | 31/08/92 |
| | | SE-A- 9004127 | 22/06/92 |